CALCIUM CARBONATE AND CALCIUM SULFATE IN MARTIAN METEORITE EETA79001.

J. L. Gooding (a) and S. J. Wentworth (b). (a) SN2/Planetary Materials Branch, NASA/Johnson Space Center, Houston, TX 77058. (b) Lockheed/EMSCO, Mail Code C23, NASA/JSC, Houston, TX.

Introduction. If shergottite meteorites are rocks ejected from Mars by impact cratering, then they might be expected to contain samples of Martian weathering products. Indeed, sulfur- and chlorine-rich minerals of apparently pre-terrestrial, low-temperature origin were previously found in samples of the shergottite, Elephant Moraine, Antarctica A79001 (EETA79001) [1,2]. Further work on additional samples has revealed the occurrence of calcium carbonate [3] and calcium sulfate in the same meteorite.

Occurrence of Carbonate and Sulfate. Chips of glassy Lithology C of EETA79001 were studied by scanning electron microscopy (SEM) and energy-dispersive x-ray spectrometry (EDS) to determine the mineralogy and petrogenesis of the glass that was shown by others [4,5] to contain trapped Mars-like gases. Calcium carbonate was identified as massive to acicular crystals for which Ca, C, and O were the major elements. Calcium sulfate was identified as prismatic-acicular crystals with Ca and S as the major elements. Additional SEM/EDS work is in progress to better more identify the minerals and their parageneses.

Ca-carbonate occurs in at least three locations in EETA79001, all of which are closely associated with glassy Lithology C. The largest deposit occurs as a drusy halo around a large glassy vug at the center of the meteorite. A second, more modest deposit occurs near the large deposit but in association with a separate, smaller glass pocket. The third deposit was recognized only after SEM/EDS reconnaissance of a chip from its glass-pocket host. The two macroscopically visible central deposits are not connected to the surface of the meteorite by any obvious system of fractures. In addition, parallel studies of demonstrably Antarctic (surface-located) weathering products in EETA79001 and other meteorites from the same field locality [6] failed to find Ca-carbonate as a terrestrially formed phase. Therefore, present physical evidence supports pre-terrestrial origin of the carbonate. Stable-isotopic analyses of C and O in the carbonate are in progress by our collaborators and should help to positively establish whether the carbonate formed in Antarctica. If an Antarctic origin can be excluded, then origin of the carbonate on Mars would become the favored interpretation.

Pre-terrestrial origin of Ca-sulfate in EETA79001 is less clear. Gypsum is a known Antarctic weathering product in the exterior of EETA79001 and in other Antarctic meteorites [6]. However, the sole occurrence of Ca-sulfate documented to date in interior samples of EETA79001 is in the intensively studied sample 27 glass pocket which has yielded the highest concentrations of trapped Mars-like gases [4,5]. Furthermore, the possibly pre-terrestrial Ca-sulfate occurs as euhedral crystals, some of which are crystallographically oriented inclusions in quench-textured pyroxenes. Other Ca-sulfate crystals in the same sample are intimately associated with Ca-carbonate and also appear to be unmelted relics. The Ca-sulfate is volumetrically less abundant than the Ca-carbonate and probably will not be separable in sufficient quantities for conventional isotopic analyses.

Implications for Martian Geology. Gooding and Muenow [2] previously hypothesized that origin of the unusual glass pockets in EETA79001, and concomitant trapping of Martian atmospheric gases, was related to shock-induced melting of pre-existing weathered (or deuterically altered) areas in the target rock. New evidence for relict grains of carbonate and

sulfate minerals in the gas-rich glass supports the Gooding-Muenow hypothesis, reiterating the unique nature of EETA79001 and the nearly inescapable conclusion that it is a Martian rock. Accordingly, the case for using EETA79001 and other shergottites for deriving geochemical properties of Mars seems to be strengthened.

Various workers have speculated about possible storage of major amounts of carbon dioxide as carbonates in the Martian regolith [7-9] although attempts to find direct evidence for carbonates in remotely-sensed data for Mars have produced negative results [10,11]. Therefore, if further work demonstrates that Ca-carbonate in EETA79001 is pre-terrestrial in origin, then we will have probably achieved the first confirmation of carbonates on Mars. In that case, geological and paleoclimatological studies of Mars need not dwell on whether carbonates exist but can concentrate on determining locations, ages, and abundances of carbonate deposits.

References:

[1] Gooding J. L. and D. W. Muenow (1985) Repts. Planet. Geol. Geophys. Program - 1985, NASA Tech. Memo. 88383, 161-163.
[2] Gooding J. L. and D. W. Muenow (1986) Geochim. Cosmochim. Acta, 50, 1049-1059.
[3] Wentworth S. J. and J. L. Gooding (1986) Meteoritics, 21, in press.
[4] Bogard D. D. and P. Johnson (1983) Science, 221, 651-654.
[5] Becker R. H. and R. O. Pepin (1984) Earth Planet. Sci. Lett., 69, 225-242.
[6] Gooding J. L. (1986) Geochim. Cosmochim. Acta, 50, 2215-2223.
[7] Fanale F. P. (1976) Icarus, 28, 179-202.
[8] Kahn R. (1985) Icarus, 62, 175-190.
[9] Haberle R. M. (1985) Nature, 318, 599-600.
[10] Singer R., T. B. McCord, R. N. Clark, J. B. Adams, and R. L. Huguenin (1979) J. Geophys. Res., 84, 8415-8426.
[11] Roush T. L., D. Blaney, T. B. McCord, and R. B. Singer (1986) Lunar Planet. Sci. XVII, Lunar and Planetary Institute, Houston, 732-733.